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SITE VISIT OF OIL SPILL UNDER MULTI-YEAR ICE AT GRIPER BAY, N.W.T.

SITE VISIT OF OIL SPILL UNDER MULTI-YEAR ICE AT GRIPER BAY, N.W.T. (September, 1982)

by

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ABSTRACT

This report describes the site conditions encountered at an AMOP experimental oil spill after five summer seasons ending September 1982. The three test sites were drilled and cored. No evidence of oil was found at any test area. All materials left on site by this and previous expeditions were removed from the site.

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1.0 SUMMARY

The AMOP experimental spill program at Griper Bay, N.W.T. was undertaken to investigate the interaction of crude oil with multi-year ice. A total quantity of 1.83 m. of Norman Wells crude oil was originally discharged at three different locations under multi-year ice on June 1, 1978. The area was overflown during the 1978 summer and a considerable amount of oil was observed on the ice surface. Site visits were made in October 1978 and March 1979; these missions failed to conclusively identify the test sites and to assess the proportion of oil still trapped within the ice to that which had surfaced. Another site visit was made during September 1979, at which time the test site locations were identified, drilled and cored. A small amount of oil was found in the ice at sites one and two (1% and 10% of the total volume of oil spilled respectively). No oil was found at site 3 as the spilled oil had surfaced due to the formation of crack through the spill site.

This report describes the results of a site visit made from September 1-5, 1982. The sites were drilled and cored to determine the amount of oil within the ice. No oil was found at any of the three sites located in September 1979. All equipment left onsite by previous expeditions was removed leaving the spill area as close as possible to its original condition. From the data gathered in 1979 and 1982 a relationship between the amount of oil remaining and the number of melt seasons since the spill has been derived. Recommendations for a further study have been made.

2.0 INTRODUCTION

The behaviour and fate of oil released in ice-infested waters is becoming of increasing concern as exploratory drilling continues in the Arctic regions. Consequently several studies have been undertaken with the aim of providing an understanding of the interaction of crude oil with Arctic sea ice.

The most extensive series of field tests involved the discharge of approximately 60 m^3 of crude oil under a first-year ice cover in 1974-75 (1). Several tests have since been undertaken in an effort to fill the remaining gaps in our knowledge which are critical. Laboratory tests, (eg. (2), (3) and (4)) have examined the spreading of Norman Wells crude oil under smooth fresh water ice and the interaction of oil and gas under a saline ice cover. Field studies have examined the interaction of oil/gas mixtures with first-year sea ice (5).

A field program has been undertaken with the objective of providing insight on the interaction of crude oil with the multi-year ice. A total of 1.83 m^3 of Norman wells crude oil was discharged at three separate sites in May 1978 under multi-year ice at Griper Bay, N.W.T., Figure 2.1 provides a location plan.

This report presents observations which were made during a visit to the spill sites in September, 1982. The field trip was undertaken to meet two broad objectives.

- to assess the quantity of oil (and its degree of weathering) still remaining at the spill sites.

- to clean up the spill site.

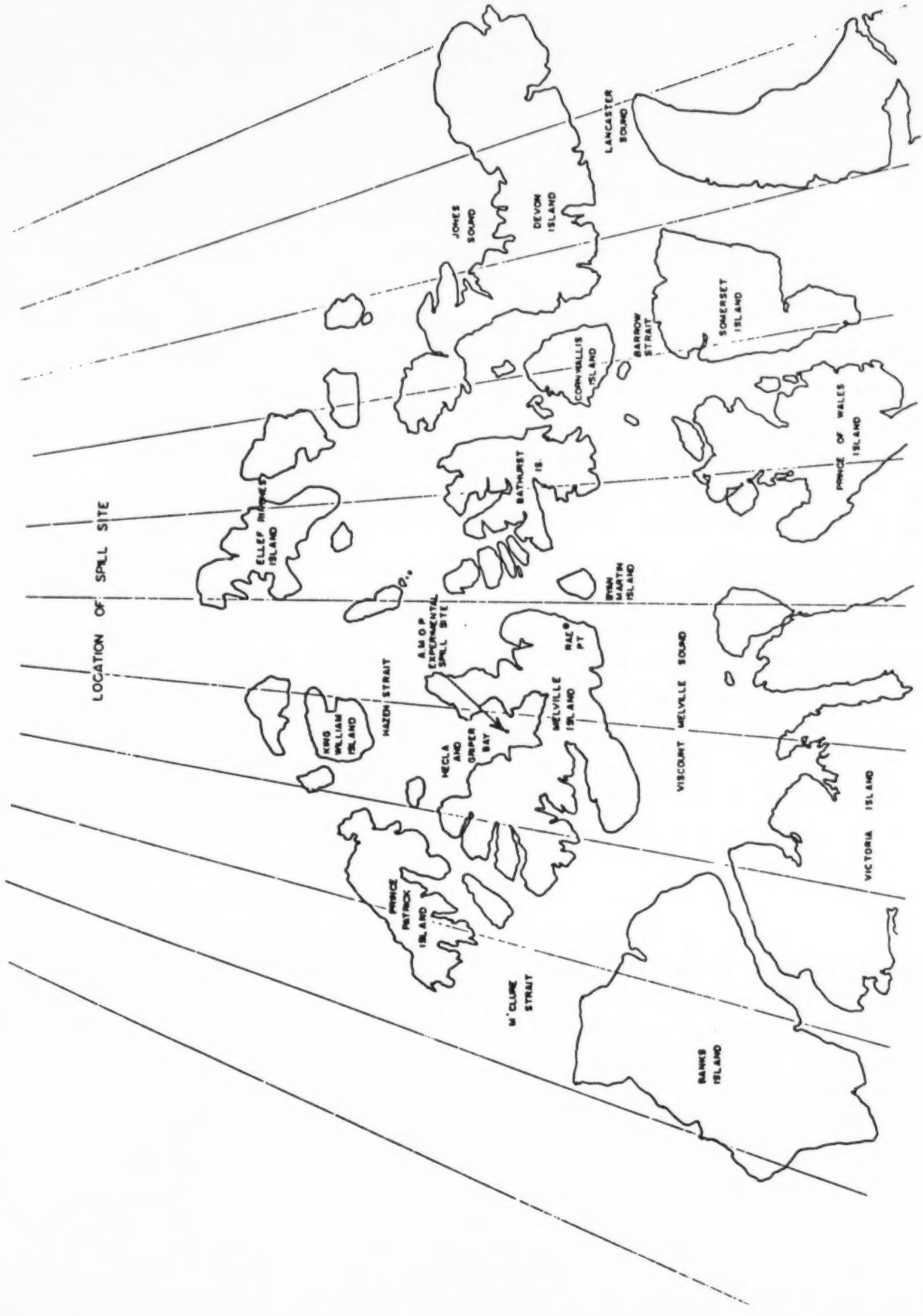

LOCATION OF SPILL SITE
LANCASTER SOUND
JONES SOUND
DEVON ISLAND
BARROW STRAIT
SOMERSET ISLAND
CORNWALLIS ISLAND
PRINCE OF WALES ISLAND
BATHURST IS.
ELLEF RINGNES ISLAND
BYAM MARTIN ISLAND
AMOP EXPERIMENTAL SPILL SITE
RAE PT
MELVILLE ISLAND
VISCOUNT MELVILLE SOUND
KING WILLIAM ISLAND
HAZEN STRAIT
HECLA AND GRIPER BAY
PRINCE PATRICK ISLAND
M'CLURE STRAIT
VICTORIA ISLAND
BANKS ISLAND

FIGURE 2.1

2.1 Synopsis of Oil Behavior to Date

The original crude oil discharges took place in 1978. The ice thickness varied from 2.5 to 2.9 m. and was at least second-year in age. Figure 2.2 shows the test site layout.

The test area was then overflown on June 13, 1978. There was no evidence of oil on the surface at that time.

The next overflight occurred on July 1, 1978. At that time, there was no evidence of oil at sites 1 and 2. However, a large crack had penetrated site 3 and oil was observed on adjacent melt pools.

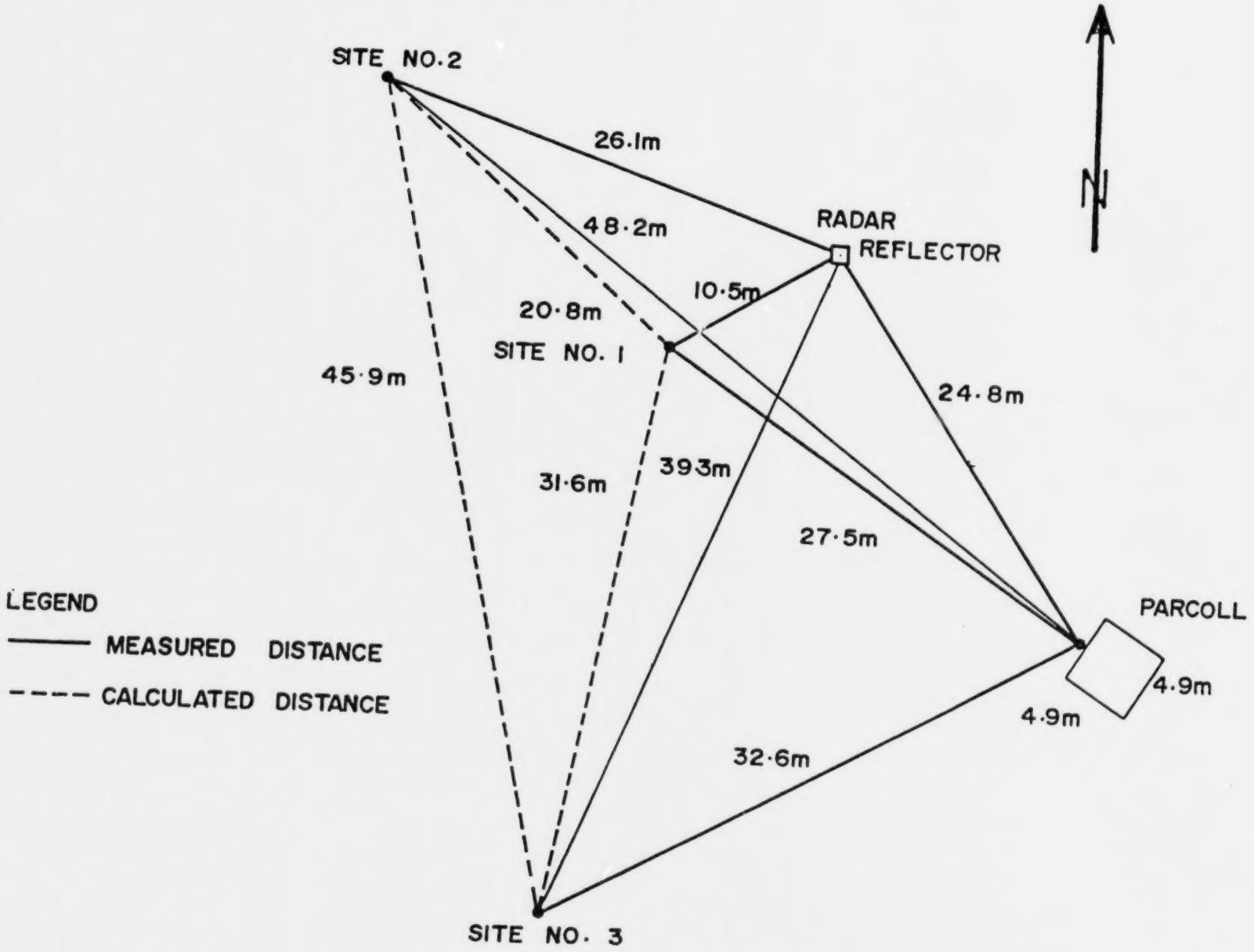
The spill sites were next overflown on August 21, 1978. Oil appeared to have surfaced, but not spread, at sites 1 and 2, while considerable oil was visible on the surface in the vicinity of site 3.

A site visit was made in October, 1978. Site 3 was cored and found to contain oil only in the top 2 to 4 cm. of the core. A core was taken in the vicinity of site 1, however no evidence of oil in the ice was found. Site 2 was not cored. No oil was visible on the surface of the spill sites.

The spill sites were next visited in March 1979. Site 3 was drilled and no oil was found within the ice sheet. The ice in the vicinity of site 1 was drilled and once again no oil was found. Site 2 was not drilled. No oil was visible on the surface of the spill sites.

In September, 1979 the sites were revisited. The location of each test site was determined from an air photo taken on August 20th. 1978, showing oil on the ice surface. This was confirmed by drill holes, suggesting the test site locations measured at the time of discharge were incorrect.

FIGURE 2.2
SITE LAYOUT



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Sites one and two were cored and a small amount of oil was found at depths of up to 1.2 m. At site three no oil was found in the ice; however on the surface of a recently frozen crack some heavily weathered oil was present. The quantity of oil still remaining in the ice sheet ranged from zero to approximately 10% of the total volume of the oil volume originally discharged. Twelve samples were selected for gas chromatographic analysis to estimate the extent of weathering of the oil remaining on the ice surface and within the ice sheet. Table 2.1 provides a brief synopsis of the study results.

SITE	1	2	3
AMOUNT OF OIL REMAINING RELATIVE TO VOLUME DISCHARGED	1%	10%	-

ESTIMATED MASS EVAPORATED	SURFACE	OIL IN ICE
MIN	37	12
MAX	43	20
MEAN	42	17

TABLE 2.1

3.0 EVENT LOG

Wednesday, September 1:

Field crew consisting of George Comfort, Luc Chabot, Tim Roots of Arctec Canada Limited and Frank Abbott of Environmental Protection Service departed Calgary at 0600 hours and arrived at Resolute at 13.30 hours. After a consultation with the P.C.S.P. coordinator, a decision to depart immediately for Cape Mudge on Griper Bay and rendezvous there with the helicopter was made. The Arctic field equipment was consolidated with the PCSP gear and supplies. The field crew and equipment left for Cape Mudge by Twin Otter at about 15:15 hours. At Cape Mudge a camp was set up as weather conditions prevented further flying. The helicopter crew confirmed that fuel was available at Sherrard Bay.

A decision was made to use Cape Mudge as a base for the helicopter and to base the field crew at either the spill site or Cape Mudge depending on which was convenient from day to day.

The weather cleared for flying at noon and the field crew was flown to the site. Before the equipment could be flown to the site the weather closed in. All work that could be performed without equipment was completed, (eg. disassembly of parcol), the spill site was tentatively located. A temporary shelter was erected from the parcol remnants and the crew spent the night on the ice.

Friday, September 3:

The weather remained below flying limits until 17:00 hours when the field crew was able to return to Cape Mudge by helicopter.

Saturday, September 4:

The crew and equipment were transferred to the site at 12:00 hours as the weather cleared. The test locations were positively identified and cores were taken. All combustible material was burned and the helicopter began to ferry the remaining material to Cape Mudge. At 18:00 hours the weather began to close in and the crew returned to Cape Mudge. Some debris was removed to Sherrard Bay for pickup and final disposal. At 22:00 hours two crew members returned to the site in preparation to complete cleanup on September 5.

Sunday, September 5:

The final cleanup on the ice was begun. Non-combustible debris was packed into boxes to be taken to Sherard Bay. The crew left the spill site at 15:00 hours having completed cleanup. All garbage was taken to Sherard Bay and the crew and equipment returned to Resolute at 20:00 hours by Twin Otter.

Monday, September 6:

The PCSP equipment was returned, Arctec field equipment was delivered to PWA for shipment south and reservations were made to fly the field crew south on Wednesday.

Wednesday, September 8:

Field crew flew south arriving in Calgary at 20:00 hours.

4.0 SURVEY TECHNIQUES

4.1 Site Description and Location

The oil spill test sites were overflown on September 2, 1982. From the air no evidence of oil could be seen. Approximately 5 cm. of fresh snow covered the site. Summer melt pools had refrozen with approximately 10 cm. of ice and were surrounded by hummocks. The parcol left on site by the field crew of 1978 was in very poor condition. Differential melt had resulted in the centre of the parcol floor rising approximately 3 m. above the surrounding terrain. No movement of ice at the site had taken place as the baseline was unchanged. Figure 4.1 shows the site in the condition found on September 2, 1982.

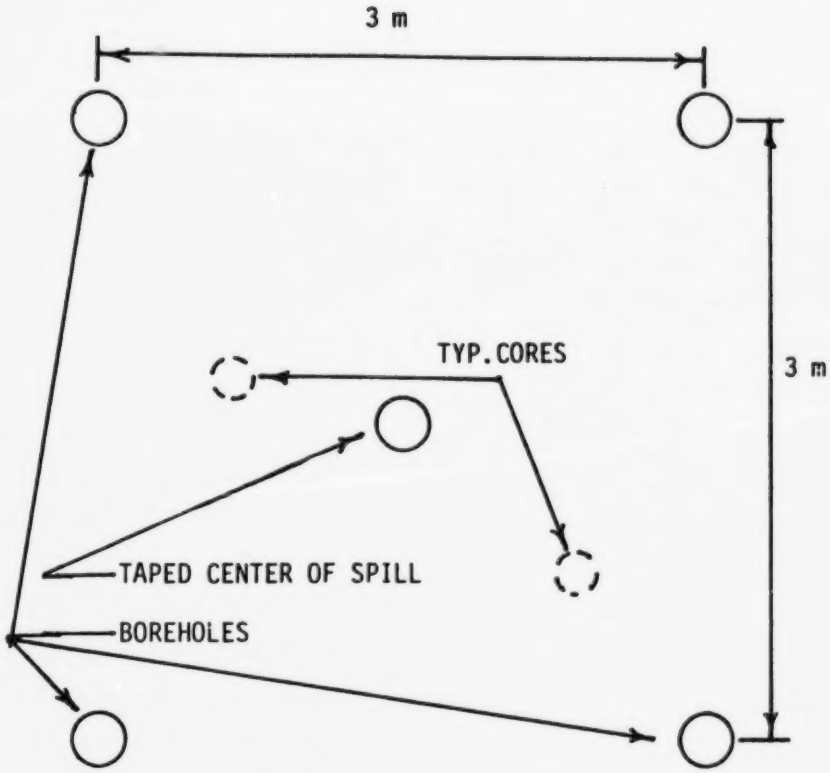
The three spill sites were located by using the site map previously reproduced as Figure 2.2.

All sites appeared to have been covered by melt pools during the recently-ended summer season. No cracks or pressure ridges were present in the area.

4.2 Site Measurements

At each of the three spill sites, holes were drilled to a depth of 1.2 metres using a 15 cm. diameter ice auger. At sites one and three five holes were drilled in a grid pattern as indicated in figure 4.2. The centre of the five holes was located at the intersections of the taped measurements from the parcol and radar reflector. The grid patterns spanned an area of 3 m. diameter about the centre hole. At site two a trace of darker material was discovered about 6 to 10 inches deep. At this location, seven holes were drilled with the auger. As each hole was drilled the shavings from the auger were examined for

FIG 4.1 SITE CONDITION UPON ARRIVAL
SEPT. 2/82



LAYOUT OF BOREHOLES

FIGURE 4.2

traces of oil. It was concluded that the dark material was windblown soil from shore which had settled in a melt pool.

Following the drilling by auger, cores were taken at each test site. One core was taken at sites one and three to the total depth of the ice cover. Two cores were taken at site two. A measurement of the ice thickness was made at each core site to ensure no part of the core was missing. Photographs were taken of the sites and are displayed as figure 4.3.

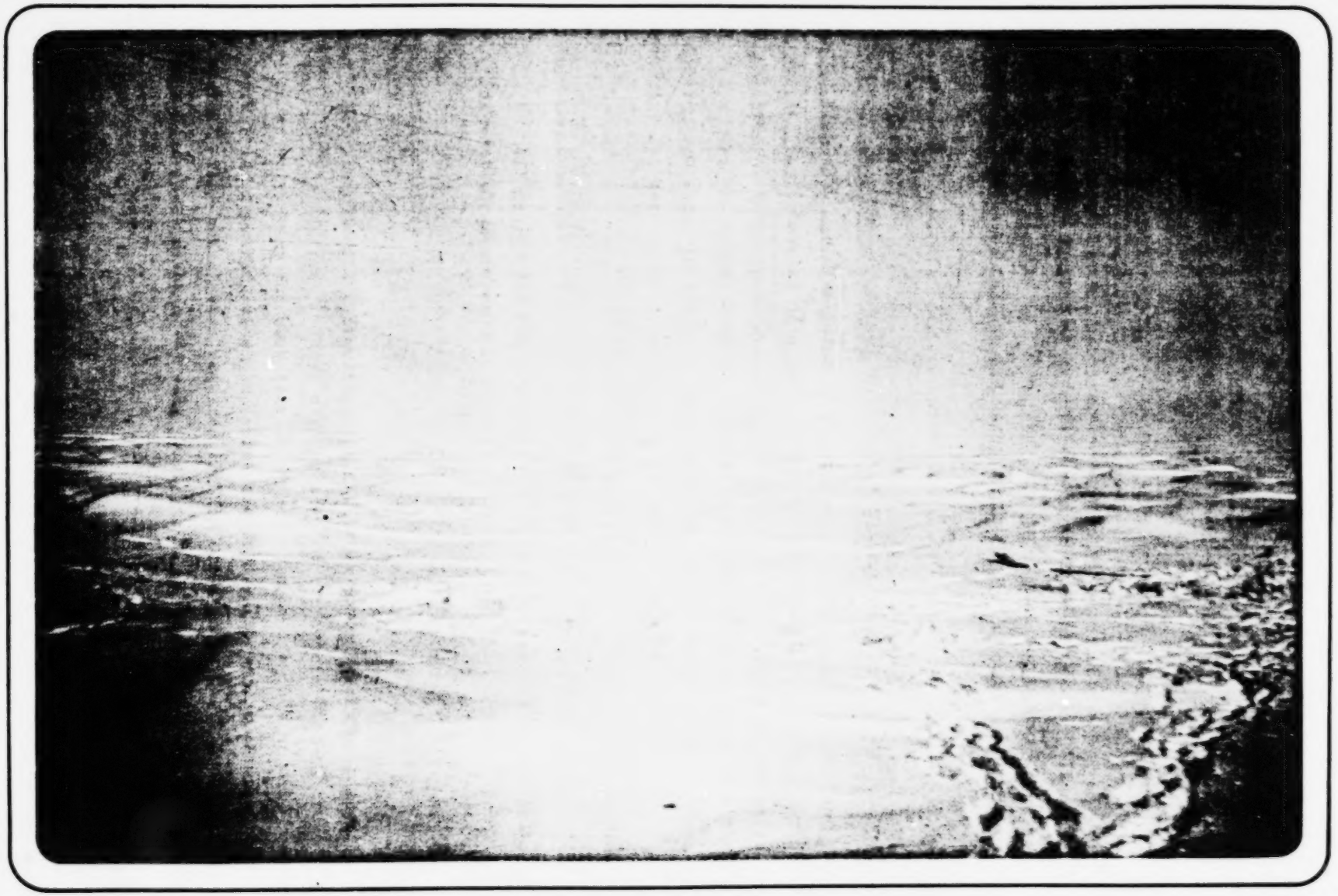


FIGURE 4.3 SITES 1 & 2

5.0 SURVEY RESULTS

5.1 Site #1:

All holes drilled at site #1 showed no traces of oil. Figure 5.1 shows an auger hole at site 1. Clean shavings were found throughout the 1.45 m. ice thickness indicating that no oil was present in the ice sheet. Figure 5.2 shows core 1.1.

5.2 Site #2:

Site #2 was also found to be free of oil Some auger holes and one core revealed small amounts of organic material near the surface. This material was identified as small particles of moss and soil. which may have collected in a melt pool over the summer season. Figure 5.3 shows an auger hole at site #2, and figure 5.4 shows core 2.1. The organic matter is shown in core 2.2 in figure 5.5. The ice thickness at site #2 was measured to be 1.8 m.

5.3 Site #3:

No oil or residue was discovered at site #3 either in auguer holes or cores. Figure 5.6 shows core 3.1.

5.4 Conclusions:

The result of the investigation indicates no oil remained trapped in the ice or on the surface. Three data points for the interaction of crude oil spilled under multi-year ice have been obtained. These are 100% of oil volume at 0 years, 10% remaining after two years and no apparent oil remaining after five years. The actual time required for the oil to disappear is not known; this could have taken place after only three years. The data can be bounded by an equation of the form:

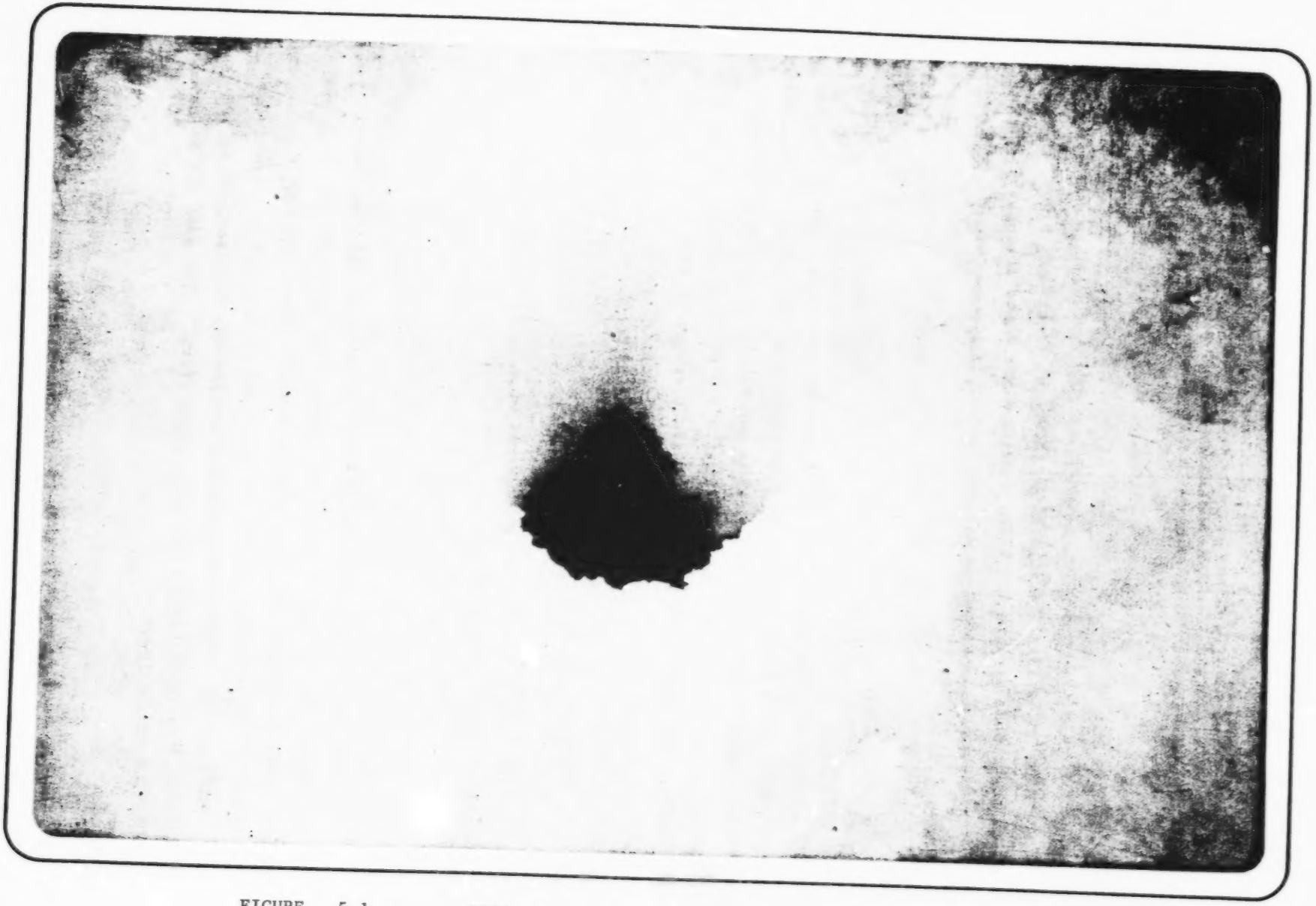


FIGURE 5.1 SITE 1 AUGER HOLE

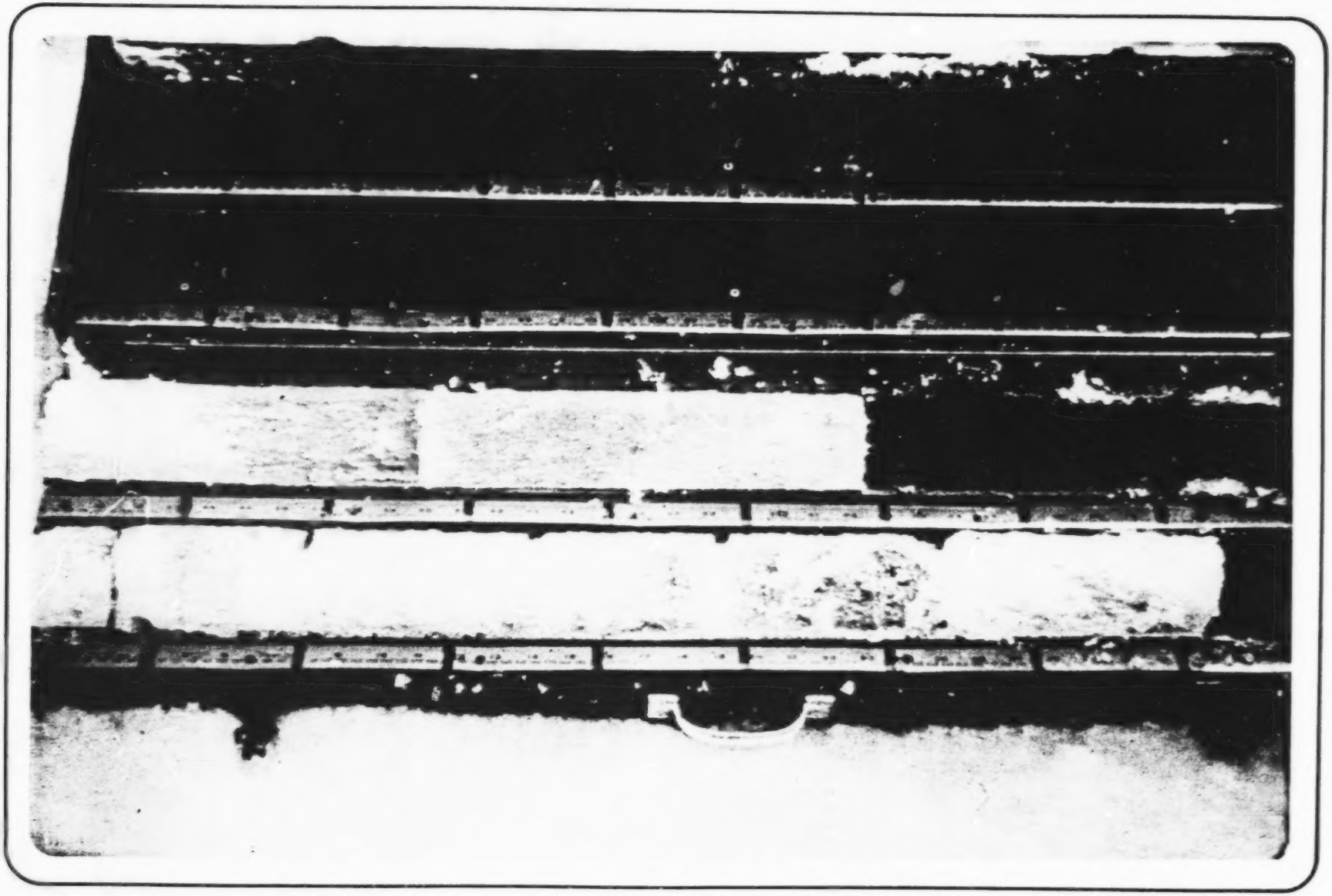


FIGURE 5.2 CORE 1.1

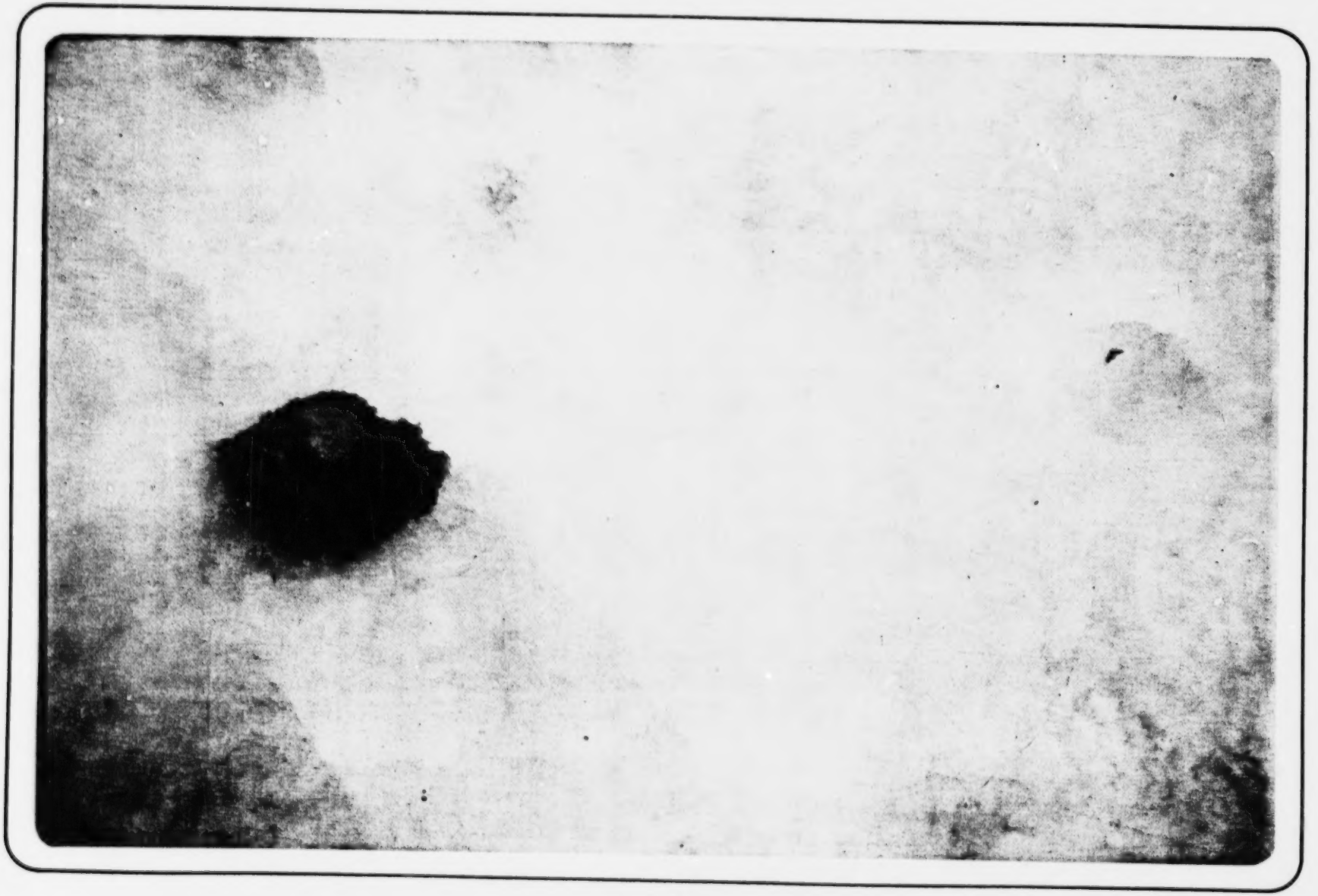


FIGURE 5.3 SITE 2 AUGER HOLE

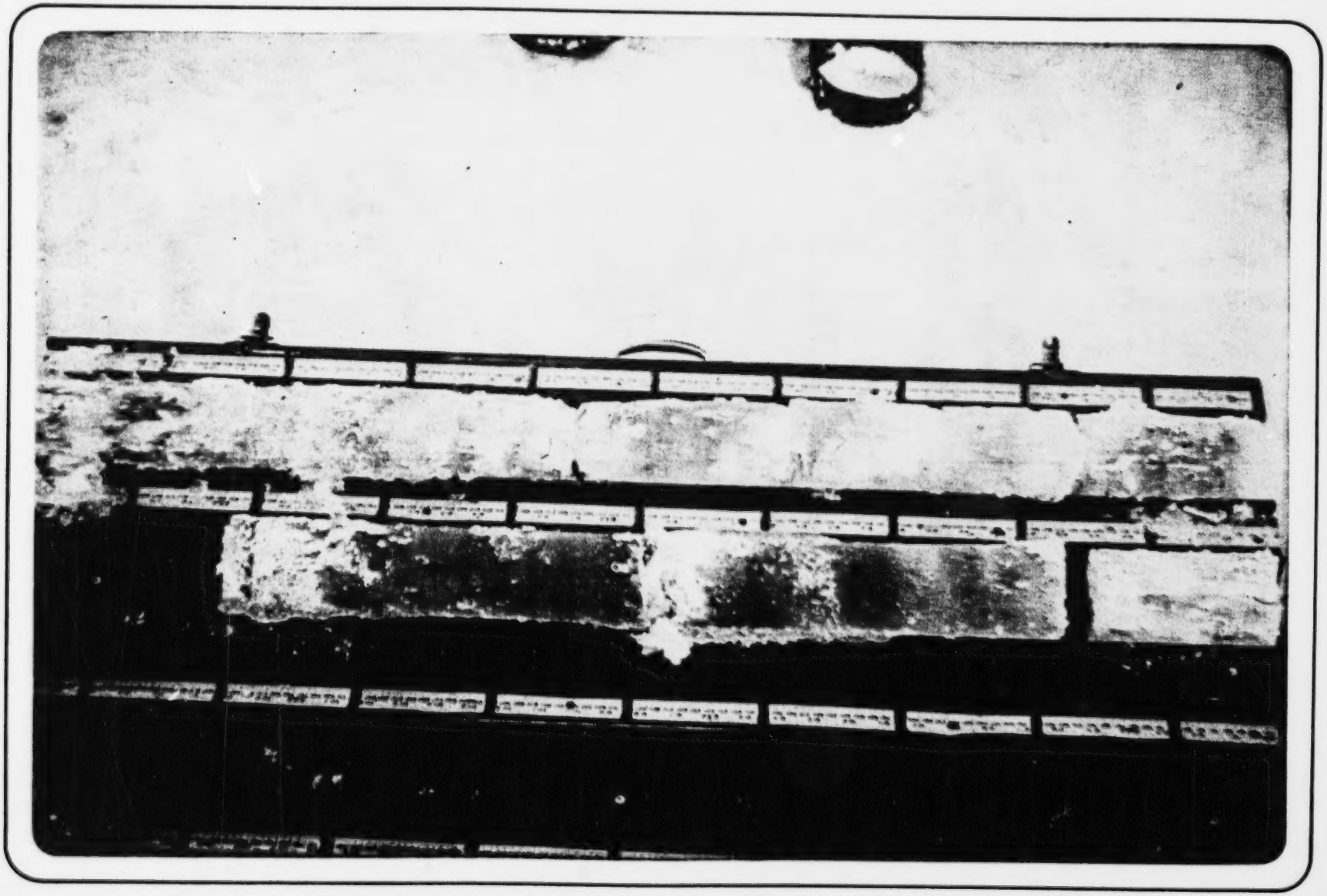


FIGURE 5.4 CORE 2.1

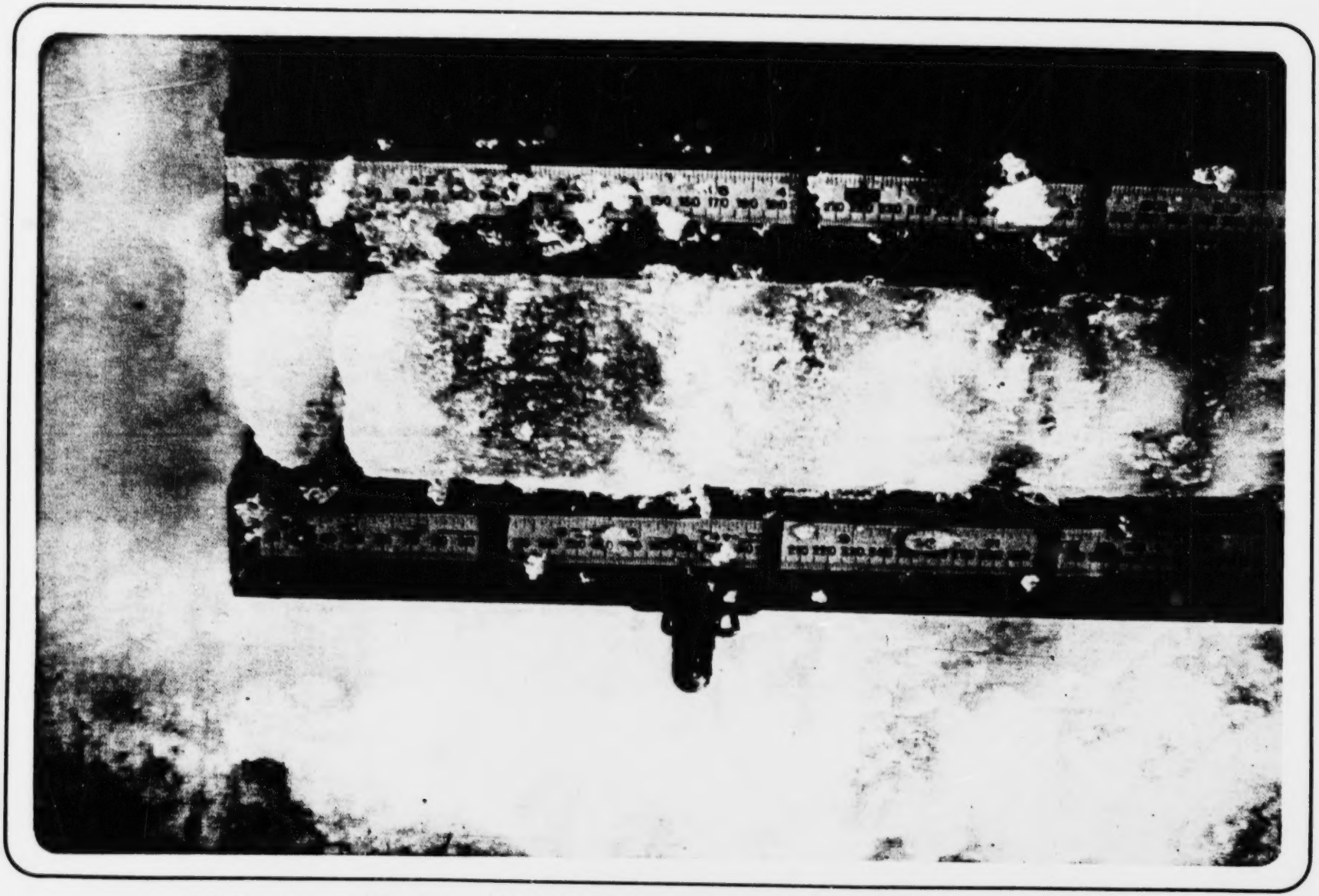


FIGURE 5.5 CORE 2.2 (AREA OF ORGANIC MATTER TO BE INDICATED)

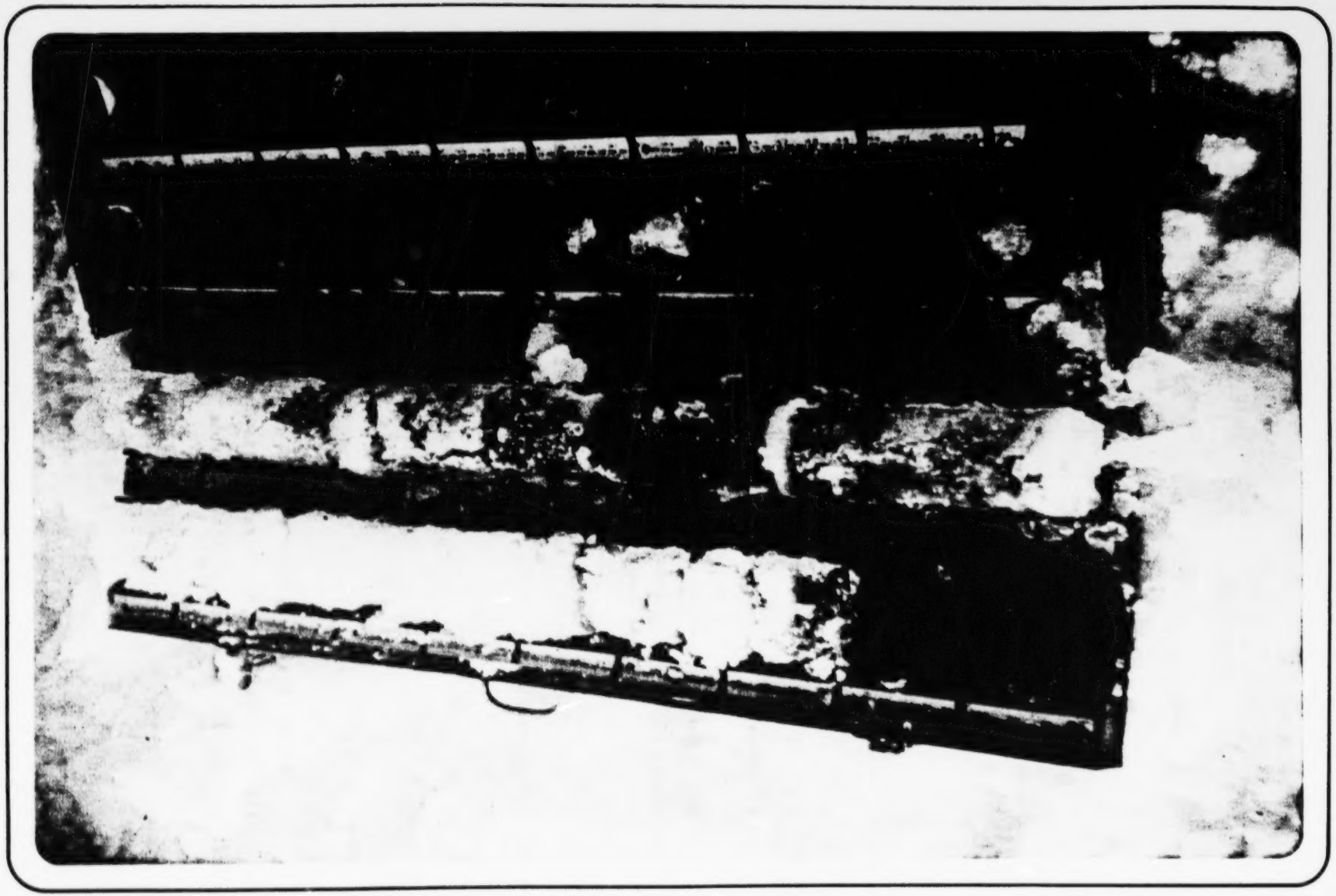


FIGURE 5.6 CORE 3.1

$$A = me^{-bt^c}$$

where for an upper bound:

A = % oil remaining
m = 100
b = 1
t = time in years
c = 1.2

This equation assumes 0.1% oil in the ice will not be noticed in a visual inspection. This is probably a very conservative estimate as much less than 0.1% of oil would likely form a visible residue.

For a low bound equation assuming 1% oil remaining after 2 years and 0.1% after 4 years.

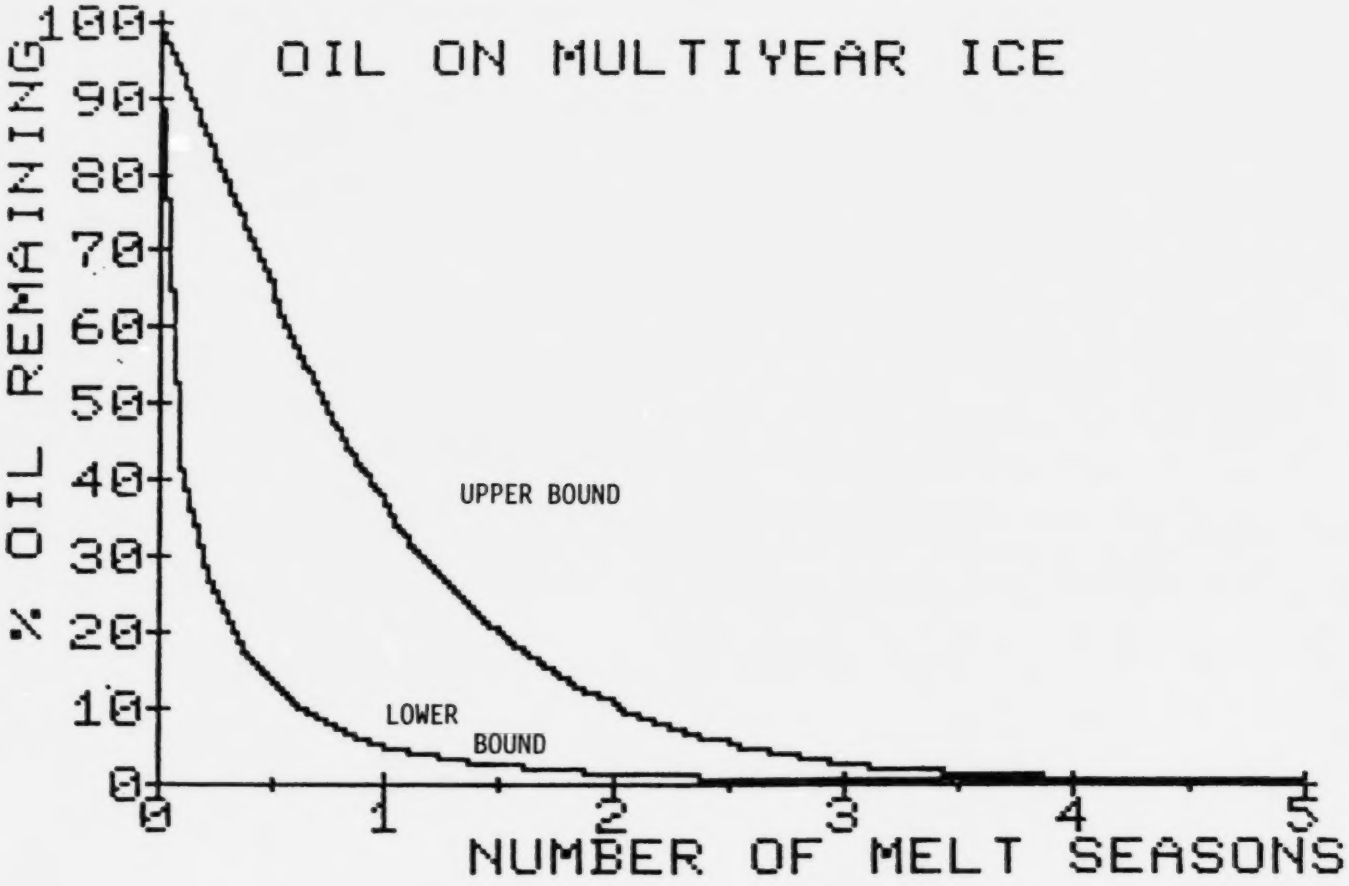
b = 3.07
c = 0.6

thus $A = 100e^{-3.07(t)^{0.6}}$

Table 5.1 lists the maximum percentage of oil remaining at 6 month intervals as predicted by these equations. As no data was taken during the first season, the accuracy of these bounds is uncertain.

UPPER BOUND $A = 100e^{-t1.2}$		LOWER BOUND $A = 100e^{-3.07t^{0.6}}$	
TIME (yrs)	OIL REMAINING (% original)	TIME (yrs)	OIL REMAINING (% original)
0.5	65.0	0.5	13.19
1.0	36.8	1.0	4.6
1.5	19.6	1.5	1.99
2.0	10.05	2.0	0.95
2.5	5.0	2.5	0.5
3.0	2.4	3.0	0.25
3.5	1.1	3.5	0.15
4.0	0.5	4.0	0.08
4.5	0.23	4.5	0.05
5.0	0.1	5.0	0.03

TABLE 5.1


OIL ON MULTIYEAR ICE
% OIL REMAINING
100
90
80
70
60
50
40
30
20
10
0
UPPER BOUND
LOWER
BOUND
0
1
2
3
4
5
NUMBER OF MELT SEASONS

GRAPH 5.1

From the results of this study it is apparent that a small crude oil spill under multi-year ice will surface quickly and completely disappear within at the most, five melt seasons. To more accurately determine the rate at which the oil disappears, further tests are required with two or more site visits per summer season until all oil has disappeared.

5.5 Recommendations

The tests have given a reasonable insight into the interaction of oil with multi-year ice. During a spill such as one caused by a well blow out, it is possible that large volumes of gas could be released with the oil. The presence of this gas may alter the behaviour of the oil under the ice. To determine the behavior a combined oil and gas spill further field tests should be performed. A more accessible site than Griper Bay, in which to perform these tests could be Committee Bay.

6.0 SITE CLEANUP

A site cleanup was effected by dismantling and burning the parcol and other combustible material. After burning was complete the debris was placed in boxes and garbage bags and removed from the site. Material such as the parcol frame, oil drums, and radar reflector was removed from the site without burning. All garbage removed from the site was taken by helicopter to the airstrip at Sherard Bay. The garbage was taken from Sherard Bay to the Panarctic camp at Rae Point for final disposal.

The site after cleanup is shown in figure 6.1 and 6.2. All foreign material had been removed from the site.

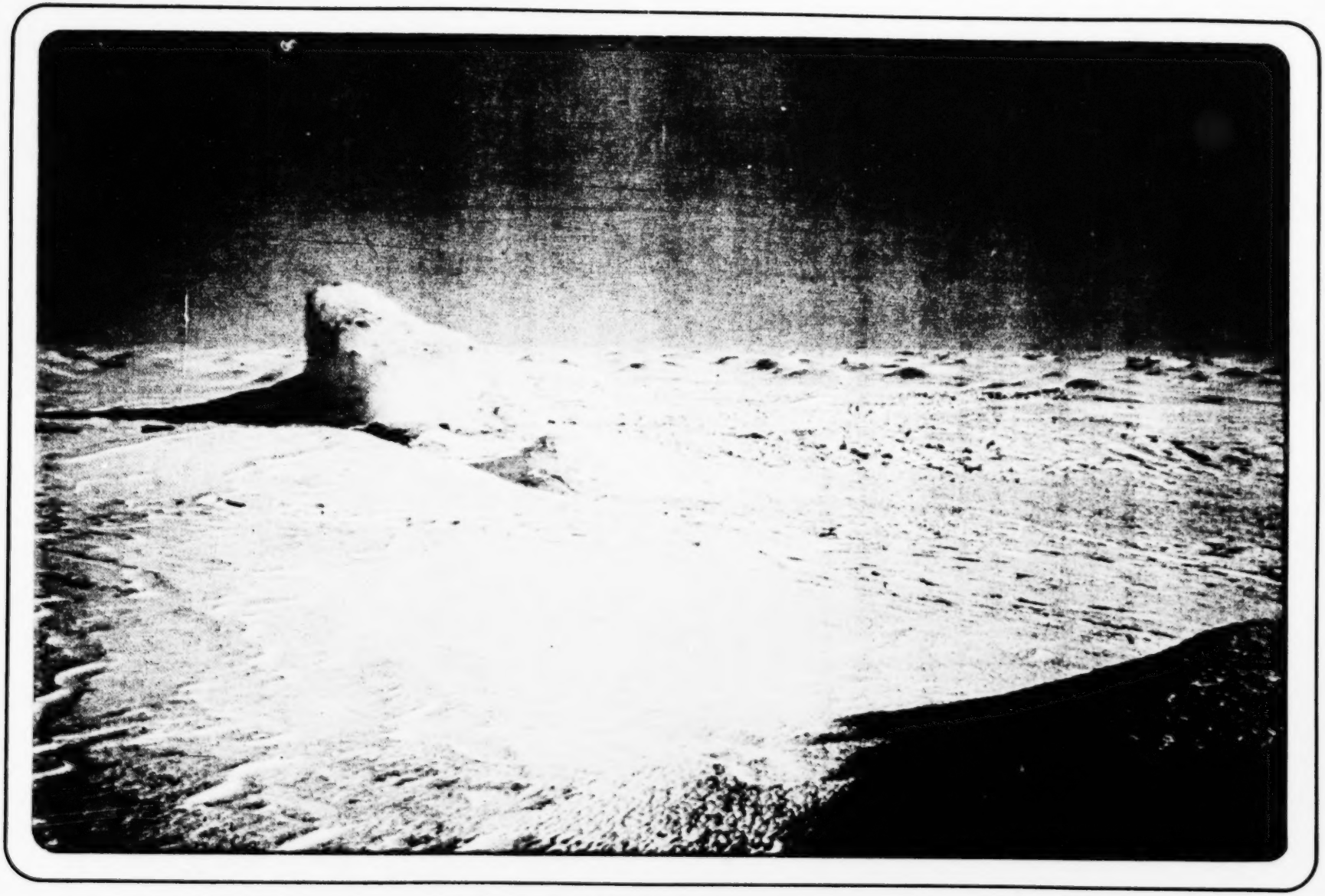


FIGURE 6.1 SITE AFTER CLEAN UP

FIGURE 6.2 REMAINS OF FIRE AFTER CLEANUP

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